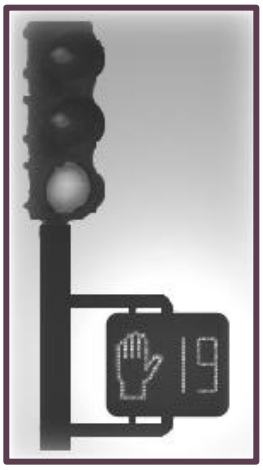
Pedestrian Countdown Signals: An Experimental Evaluation

Volume 1



Jan L. Botha, Ph.D.
Aleksandr A. Zabyshny
Jennifer E. Day

San Jose State University
Department of Civil and Environmental Engineering

Ron L. Northouse, P.E.
Jaime O. Rodriguez
Tamara L. Nix

City of San Jose Department of Transportation

May 2002

BACKGROUND AND INTRODUCTION

The countdown signal displays flashing numbers that count down the time remaining until the end of the flashing "DON'T WALK" (FDW) interval. The countdown display, which can start at the onset of either the WALK or the FDW display, reaches zero and blanks out at the onset of the steady "DON'T WALK" (DW) display. When the countdown starts at the beginning of the FDW, the duration of the countdown is approximately equal to the pedestrian clearance interval for the crosswalk (the duration may vary according to local signal timing practice). This issue is discussed later in this report.

The first installation of countdown signals in California occurred in Sacramento County in 1998. Since that time, many cities have installed countdown signals. The City of San Jose made a request to the California Traffic Control Devices Committee (CTCDC) to install these signals on an experimental basis at five intersections to study their effectiveness. In November 2000, the request was granted to install the signals at five intersections for testing.

For the San Jose study, the countdown accompanying the FDW display (as illustrated below) was tested.

WALK

FDW

DW

According to Huang and Zegeer (1) the principal motivation for the pedestrian countdown signal is to aid pedestrians in getting out of the street before they would be exposed to oncoming motor vehicles. However, during deliberation at the CTCDC meeting in June 2001 to develop standards for the various agencies testing the devices in California, several issues were raised that needed to be addressed regarding the operation of the countdown signals. The following questions arose:

- Could the public incorrectly interpret the countdown display to mean that it is permitted to leave the curb as long as it is possible to complete the crossing before the countdown reaches zero?
- Would erratic behavior of pedestrians, such as running, hesitating or turning around in the crosswalk increase?
- Would the incidence of motorists entering the intersection on yellow or red increase?

The above issues were addressed in the San Jose study and are discussed in this report. In addition, it was considered important to gain some understanding of other related issues, such as pedestrians' ability to judge how long it would take to clear a crosswalk. To gain perspective on safety issues, studies of crash history and pedestrian-vehicle conflicts at the study sites were undertaken.

The objective of this report is to present the results of the study of the performance of the countdown signals in the City of San Jose, including relevant data gathered at other intersections in the city, conclusions and recommendations.

The report is presented in two volumes. Volume 1 contains an overview of existing studies and other relevant literature, the study approach, relevant information on the study sites, results of the study of pedestrian behavior, motorist behavior, traffic conflicts and crash analysis. An overview of existing practices for pedestrian signal timing in California, together with information on incorporating countdown signals in timing procedures, is provided. A summary of the major conclusions as well as a discussion and recommendations follow. Volume 2 consists of appendices that contain more detailed reports of data collection and analysis.

REVIEW OF EXISTING DOCUMENTATION

The California Vehicle Code 2002 Edition (2) states the lawful actions of pedestrians when confronted pedestrian signal displays as:

> "(a) 'Walk' or Approved 'Walking Person' symbol. A pedestrian facing the signal may proceed across the roadway in the direction of the signal, but shall yield the right-of-way to vehicles lawfully within the intersection at the time that signal is first shown.
>
> (b) Flashing or steady 'DONT WALK' or 'WAIT' or approved 'Upraised Hand' symbol. No pedestrian shall start to cross the roadway in the direction of the signal, but any pedestrian who has partially completed crossing shall proceed to a sidewalk or safety zone or otherwise leave the roadway while the 'WAIT' or 'DONT WALK' or approved 'Upraised Hand' symbol is showing."

The code further states that it "..shall be unlawful for any pedestrian to fail to obey any sign or signal erected or maintained to indicate or carry out the provisions of this code.."

That conventional FDW signals are misunderstood by a significant percentage of pedestrians is a phenomenon that does not seem to be in dispute. Literature on Canadian crosswalk research prepared for the U.S. Department of Transportation's Federal Highway Administration (3) reports that 80 percent of pedestrians surveyed inaccurately interpreted the pedestrian clearance phase of the FDW display. Robertson, et. al. found that about half of pedestrians understood the FDW display (4). Surveys in Hampton, Virginia, indicated that 25 percent of pedestrians do not understand the meaning of FDW signal heads (5).

The results of other studies vary, but the message is the same: many pedestrians are inappropriately interpreting the message sent by FDW signals. There also seems to be general agreement regarding the results of the aforementioned misinterpretations. Some people perceive a flashing hand or a FDW message to mean that they can enter the intersection because the

steady hand or DW message is not yet displayed (1). Others, particularly the elderly, see the FDW command and return to their origin curb (6).

The findings on the effectiveness of countdown pedestrian signal heads are less conclusive. The assumption underlying this variety of pedestrian signal is that pedestrians that know how much time they have left to cross are better informed and, as a result, make better decisions when crossing the street. Some research supports this theory; some refutes it.

For instance, a study by the Minnesota Department of Transportation (7) found that crosswalk signal modifications that included pedestrian countdown signals increased "successful crossings" from 67 percent to 75 percent, and improvements for the elderly were even more dramatic. It is noteworthy, though, that a "successful crossing" was defined as a crossing that began during the WALK or FDW phase of the pedestrian signal and ended before the steady DW indication. The incidence of pedestrians leaving the curb during the WALK indication and finishing during the WALK or FDW indication increased less dramatically, from 55 percent before the installation to 62 percent after. Furthermore, the incidence of pedestrians starting on FDW or DW and finishing after the DW displays, increased from 6 to 12 percent. A majority of pedestrians indicated that they understood the meaning of the countdown signals.

Study data from San Francisco (4) indicate that the number of pedestrians clearing the intersection after the FDW phase decreased significantly after countdown installation. It should be noted that the higher incidence of successful crossings is mostly attributed to pedestrians quickening their pace in response to the countdown display. The study reports a slight decrease in the incidence of pedestrians entering the intersection on the FDW from the before to the after installation periods, as well as decreases in pedestrian/vehicle conflicts and erratic pedestrian behavior in the crosswalk. Additionally, the report identifies a decrease in pedestrians' understanding that starting to cross during the FDW phase is a violation. Interestingly, although 92 percent of pedestrians said that countdown signals are "more helpful" than conventional signals, the proportion of pedestrians who properly interpret the FDW display decreased from 40 percent before to 17 percent after the implementation of the countdown signal. It was also noted

in the study findings that "pedestrians are using the countdown signals to decide when to start to cross," but that the presence of the countdown signal did not affect the likelihood of a pedestrian leaving the curb during the FDW. Pedestrians in San Francisco stated that they found the signal to be helpful because it showed the time remaining to cross, but the data do not indicate a significant change in lawful crosswalk entry as a result of the countdown device. Additionally, the report states that the positive impacts on pedestrians' behavior, particularly that they are not more likely to leave the curb during the FDW interval, are more significant than pedestrians' misinterpretation of the FDW display.

Similar findings in Quebec indicate that the presence of countdown devices reduced pedestrian/traffic conflicts significantly, though the actual significance of the reduction is unclear because specific data supporting this conclusion was not included in the report (8). Research was also conducted in the City of Monterey (6) on pedestrian behavior, but only during the after situation, which does not allow for a comparative analysis. Surveys from the Monterey study indicated that most pedestrians understood the meaning of the signal, and researchers suggest that pedestrians who do not understand the signal can "at least…rely on the time indicated on the countdown to dictate their behavior."

One study conducted in the City of Saint-Laurent in Quebec, Canada, surveyed over 4000 pedestrians and found that 80 percent of pedestrians did not understand the FDW display. Follow-up research showed that the presence of countdown signal heads did not increase their understanding. In another study of eight intersections in six Quebec municipalities, a yellow-silhouetted figure phase was added between the white-silhouetted figure phase (signifying "WALK") and a red-silhouetted figure phase (signifying "DON'T WALK") to indicate an interim message, "DON'T BEGIN TO WALK." This study concluded that pedestrians better understood the message of the tri-colored signal head; however, the incidence of compliance did not increase. Another study in Toulouse, France, found no significant change in pedestrian behavior following installation of countdown displays (3).

Research prepared for the Federal Highway Administration (1) indicates that pedestrian

countdown signals had a greater negative than positive impact on pedestrian safety in test sites in Sacramento County, California. They found that the proportion of pedestrians who complied with the WALK phase decreased from 82 percent to 68 percent, and the proportion finishing after time ran out increased from 11 percent to 17 percent. They also stated that the signal might be inducing pedestrians to enter the crossing on the FDW. The same study concludes that the percentage of pedestrians conflicting with oncoming traffic increased significantly, that pedestrian countdown signals need further testing to ascertain their effects, and that alternatives other than countdown signals can be more effective in improving pedestrian safety.

From the above discussion, it appears that the countdown signals may cause pedestrians to enter the crosswalk during the FDW interval. In most cases, there was an indication that the signal may aid the pedestrians in exiting the crosswalk before the DW interval. However, it is notable that in some of the studies that emphasized this positive aspect, the proportion of pedestrians entering the crosswalk inappropriately was not studied. Moreover, in two of these studies, specific mention was made of the fact that the device was not intended to stop the pedestrians from entering the crosswalk during the FDW interval. In the case of the San Francisco study, researchers state that the study alerted them to the potentially-significant incidence of improper interpretation of the signals by pedestrians, but the report also states that entry on FDW is not the City's "official policy" and that the behavioral changes observed after the installation were of sufficient merit to outweigh the lack of pedestrian understanding of the FDW display. The statement that San Francisco does not accept entry on the FDW as official policy does not, of course, prevent the pedestrians from entering the intersection on the FDW.

In several surveys, pedestrians responded that the meaning of the countdown was clear to them, yet data gathered indicate that the countdown display has made the FDW interval increasingly unclear. The implication here is that pedestrians show a high degree of confidence that their erroneous interpretations are accurate. Because of this conflict, pedestrian statements regarding the clarity of countdown signals should not necessarily be taken to mean that the installation of the signal is beneficial. It may just mean that they understand that the signal shows the time remaining, but not that they are meant to wait if a countdown is displayed.

BASIC APPROACH TO THE EVALUATION

The San Jose evaluation focused on gaining an understanding of the performance of the countdown signal in five categories discussed in the introduction. These five categories of questions are:

- Does the countdown signal aid pedestrians in getting out of the street before they would be exposed to the danger of oncoming motor vehicles?
- Does the countdown signal cause pedestrians to leave the curb during the FDW phase because they think that they have time to complete the crossing before the countdown reaches zero?
- Does the countdown signal reduce erratic behavior of pedestrians, such as running, hesitating or turning around in the crosswalk?
- Does the countdown signal increase the incidence of motorists entering the intersection on yellow or red?
- Does the countdown signal increase safety?

The performance of the signal was assessed by conducting operations studies, pedestrian surveys, conflict analysis and the review of crash data. Where appropriate, studies were conducted before the installation of the new signal as well as after. The before studies commenced in March 2001 and continued through May 2001. The after studies took place during the period September 2001 through March 2002. The countdown signals were installed at the following intersections (dates of installation are shown in parentheses):

- Market Street & St. John Street (6/12/2001)
- Eleventh Street & San Antonio Street (7/13/2001)
- Santa Clara Street & Twenty-first Street (9/6/2001)
- Market Street & San Carlos Street (9/5/2001)
- Convention Center & San Carlos Street (9/5/2001) (pedestrian crossing)

After the initial "before" studies, it was decided that the intersection of Eleventh and San Antonio would be omitted, because pedestrian volumes were low. It was decided to use the

available resources to gather more data at other test sites. For a part of the study, comparative sites, without the countdown signals, were utilized. These sites were the intersections at Almaden Boulevard & San Carlos Street and at Market & Santa Clara Streets.

Overviews of the study methods are presented in the following sections.

Operations Studies

The operations studies consisted of assessing pedestrian compliance, pedestrian walking speeds and motorist behavior.

The overall goal of the pedestrian compliance study was to assess the incidence of non-compliance to the pedestrian signal and unusual or "erratic" pedestrian movements. The objective of the first part of the pedestrian compliance study was to assess the proportion of pedestrians arriving during the DW or FDW displays that waited for the WALK signal before crossing the street. During the second part of the compliance study the proportions of all pedestrians that entered the crosswalk during the WALK, FDW and DW intervals were measured. The third part of this study was aimed at measuring the performance of the signal in getting the pedestrians safely out of the crosswalk. To this end, the numbers of pedestrians exiting the crosswalk on the WALK, FDW and DW were observed. In the last part of the compliance study, the proportions of pedestrians running, stopping/hesitating or turning-around were measured. In addition, the proportion of pedestrians involved in a conflict with a vehicle was also measured.

Pedestrian walking speeds were measured at the study sites to determine whether, on the average, pedestrians could be encouraged by the new signal to enter the crosswalk on the FDW and be rushed to complete their crossing by changes in their behavior. The proportions of motorists entering the intersection on yellow or red were monitored to determine whether the new signal increased the number of motorists entering on yellow or red.

All of the above studies were conducted for the before and after installation situations.

Pedestrian Surveys

The principal objective of the pedestrian surveys was to gain further understanding of the public's interpretation of the countdown signal.

The pedestrians were asked to estimate the time it would take to cross a street. The intent here was to determine whether pedestrians could correctly estimate the time that it takes to cross a particular street. This survey was administered at locations without the countdown device. If they did underestimate the time to cross, this would imply a negative effect of the countdown signal in that it may cause pedestrians to enter the crosswalk during the FDW display and into a situation where they could potentially have insufficient time to cross.

The question was also posed as to whether it was permitted to enter on the FDW, at locations with and without the new signals. The question was also posed in a slightly different way at the locations with countdown signals to get a more direct interpretation of the meaning of the countdown itself.

Safety Studies

An analysis of crashes involving pedestrians was conducted at the study sites, for approximately three years before installation of the countdown signals, and approximately four months after the signals were installed. Since there were too few such crashes to make a statistical comparison of crash characteristics between the before and after periods, the crash reports were read to gain insight as to whether misinterpretation of the FDW display was responsible for the crashes.

A conflict study was carried out before and after installation to establish any differences in conflict occurrence between the before and after period. All studies and surveys were first tested

in the field, and then modified based on this experience. Vehicle and pedestrian volume counts were conducted where and when appropriate.

THE STUDY SITES

Sketches, showing pertinent site characteristics are presented in Figures 1 through 6. Other relevant information is provided below for the four principal study sites (those with countdown signals) as well as for the two supplemental sites (those without countdown signals).

The Principal Study Sites – With Countdown Signals

Market Street & San Carlos Street

Located in downtown San Jose, this intersection is adjacent to the McEnery Convention Center, the San Jose Civic Auditorium, and Plaza De Cesar Chavez Park. During conventions, high pedestrian volumes often include many tourists. The Valley Transportation Authority (VTA) light rail travels through this intersection along San Carlos Street. This is a nine-phase traffic signal (seven vehicle phases and two light-rail phases), with pedestrian push buttons for all four pedestrian phases, and is not coordinated with other signals. The pedestrian phases are timed as follows:

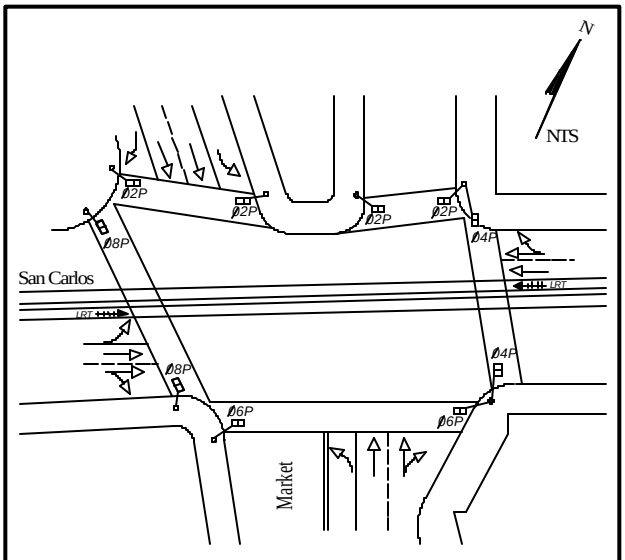


Figure 1. Market & San Carlos

Pedestrian ϕ2 (North-leg crosswalk) has a 9-second WALK interval and a 19-second FDW interval, followed by a 3-second "Yellow" interval, and a 1.5-second "All Red" interval.

Pedestrian ϕ4 (East-leg crosswalk) has a 9-second WALK interval and a 22-second FDW interval, followed by a 3-second "Yellow"

interval, and a 1-second "All Red" interval.

Pedestrian ϕ6 (South-leg crosswalk) has a 9-second WALK interval and a 31-second FDW interval, followed by a 3-second "Yellow" interval, and a 1.5-second "All Red" interval.

Pedestrian ϕ8 (West-leg crosswalk) has a 9-second WALK interval and a 28-second FDW interval, followed by a 3-second "Yellow" interval, and a 1-second "All Red" interval.

Market Street & St. John Street

Located in downtown San Jose, this intersection is adjacent to the San Jose Post Office, parking structures, and office buildings. This is a two-phase traffic signal with left-turn pockets on all four legs, and pedestrian push buttons for both pedestrian phases. This traffic signal is coordinated with other signals along Market Street, so the WALK interval for the corresponding pedestrian phase will vary. The pedestrian phases are timed as follows:

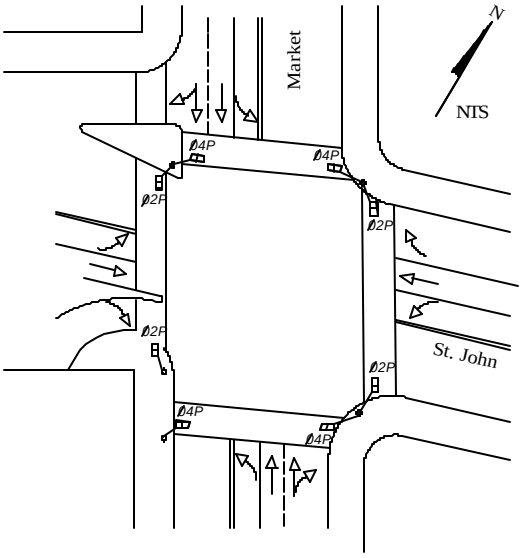


Figure 2. Market & St. John

Pedestrian ϕ2 (East-leg and West-leg crosswalks) has a minimum 5-second WALK interval and a 19-second FDW interval, followed by a 3-second "Yellow" interval, and a 1-second "All Red" interval.

Pedestrian ϕ4 (North-leg and South-leg crosswalks) has a 5-second WALK interval and a 19-second FDW interval, followed by a 3-second "Yellow" interval, and a 1-second "All Red" interval.

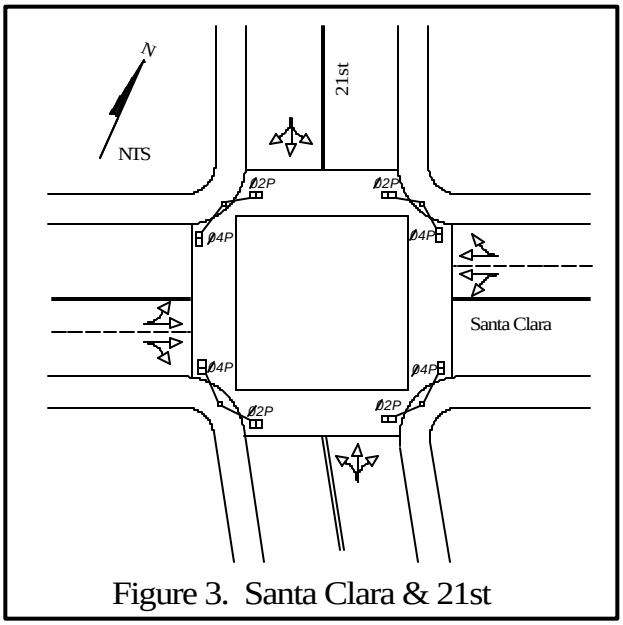


Figure 3. Santa Clara & 21st

Santa Clara Street & Twenty-first Street

Located just east of downtown San Jose, this intersection is near San Jose Academy High School, and lies within both a residential (to the North and South) and commercial (to the East and West) area. This is a two-phase traffic signal with no left-turn pockets, although left-turn movements are permitted from all approaches. There is no vehicle detection system, and no pedestrian push buttons. This traffic signal is coordinated with other signals along Santa Clara Street, so the WALK interval for the corresponding pedestrian phase will vary. The pedestrian phases are timed as follows:

Pedestrian ϕ2 (North-leg and South-leg crosswalks) has a minimum 5-second WALK interval and a 14-second FDW interval, followed by a 3-second "Yellow" interval, and a 1-second "All Red" interval.

Pedestrian ϕ4 (East-leg and West-leg crosswalks) has a 5-second WALK interval and a 12-second FDW interval, followed by a 3-second "Yellow" interval, and a 1-second "All Red" interval.

Convention Center & San Carlos Street

This is a mid-block signalized pedestrian crossing located in downtown San Jose on San Carlos Street between Market Street and

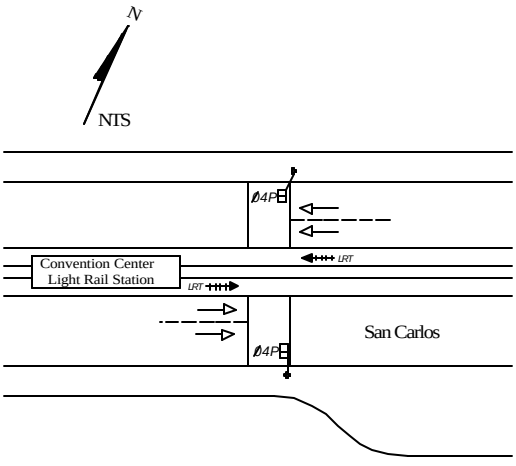


Figure 4. Convention Center & San Carlos

Almaden Boulevard. The crosswalk extends from the San Jose Civic Auditorium (on the north side of San Carlos) to the McEnery Convention Center and the main branch of the San Jose Public Library on the south. During conventions, high pedestrian volumes often include many tourists. The VTA light rail travels along San Carlos through this pedestrian crossing, with a light rail station located just west of the crosswalk. This is a four-phase traffic signal that utilizes pedestrian push buttons.

Pedestrian ϕ4 has an 8-second WALK interval and a 26-second FDW interval, followed by a 3-second "All Red" interval.

Supplemental Sites – Without Countdown Signals

Almaden Boulevard & San Carlos Street

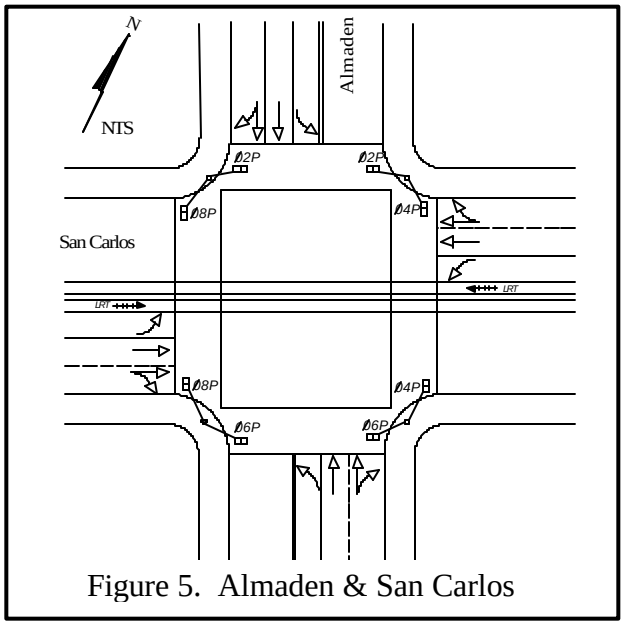


Figure 5. Almaden & San Carlos

Located in downtown San Jose, this intersection is adjacent to the Center for the Performing Arts, the San Jose Civic Auditorium, the Hilton & Towers Hotel, and a public parking lot. During events at the city facilities located at and near this intersection, there are high pedestrian volumes, including many tourists. The VTA light rail travels through this intersection along San Carlos Street. This traffic signal utilizes conventional pedestrian signals (without countdown) and was selected for pedestrian surveys at a non-countdown signal location due to it's similar geometric, geographic, and traffic signal design and timing characteristics with Market Street & San Carlos Street. This is a ten-phase traffic signal (eight vehicle phases and two light-rail phases), with pedestrian push buttons for all four pedestrian phases, and is not coordinated with other signals. The pedestrian phases are timed as follows:

Pedestrian ϕ2 (North-leg crosswalk) has a 9-second WALK interval and a 30-second FDW interval, followed by a 3-second "Yellow" interval, and a 1-second "All Red" interval.

Pedestrian ϕ4 (East-leg crosswalk) has a 9-second WALK interval and a 28-second FDW interval, followed by a 3.5-second "Yellow" interval, and a 1-second "All Red" interval.

Pedestrian ϕ6 (South-leg crosswalk) has a 9-second WALK interval and a 33-second FDW interval, followed by a 3-second "Yellow" interval, and a 1-second "All Red" interval.

Pedestrian ϕ8 (West-leg crosswalk) has a 9-second FDW interval and a 27-second FDW interval, followed by a 3.5-second "Yellow" interval, and a 1-second "All Red" interval.

Market Street & Santa Clara Street

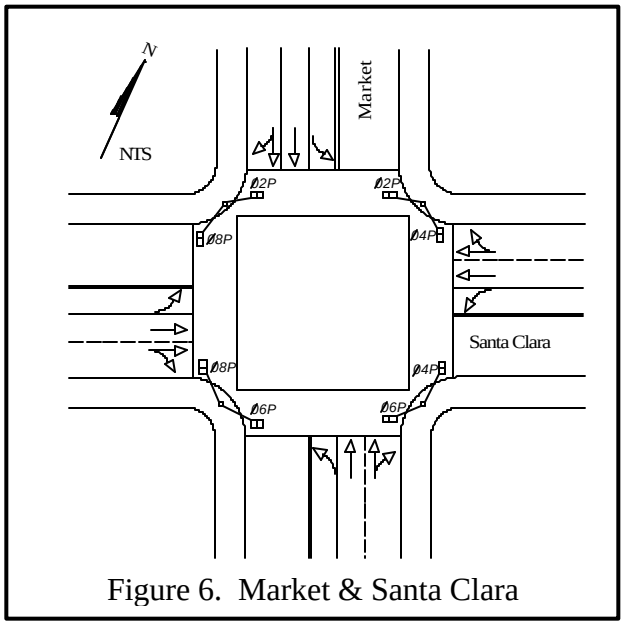


Figure 6. Market & Santa Clara

Located in downtown San Jose, this intersection is adjacent to office buildings and near a variety of downtown business establishments. This traffic signal utilizes conventional pedestrian signals (without countdown) and was selected for pedestrian surveys at a non-countdown signal location due to it's similar geometric, geographic, and traffic signal timing characteristics with Market Street & St. John Street. This is a six-phase traffic signal with protected left-turns on Market Street, left-turn pockets on Santa Clara Street, and pedestrian push buttons for all pedestrian phases. This traffic signal is coordinated with other signals along Market Street, so the WALK interval for the corresponding pedestrian phase will vary. The pedestrian phases are timed as follows:

Pedestrian ϕ2 (North-leg crosswalk) has a 5-second WALK interval and an 18-second FDW interval, followed by a 3-second "Yellow" interval, and a 2-second "All Red" interval.

Pedestrian ϕ4 (East-leg crosswalk) has a minimum 5-second WALK interval and a 19-second FDW interval, followed by a 3-second "Yellow" interval, and a 2-second "All Red" interval.
Pedestrian ϕ6 (South-leg crosswalk) has a 5-second WALK interval and a 18-second FDW interval, followed by a 3-second "Yellow" interval, and a 2-second "All Red" interval.

Pedestrian ϕ8 (West-leg crosswalk) has a minimum 5-second WALK interval and a 19-second FDW interval, followed by a 3-second "Yellow" interval, and a 2-second "All Red" interval.

PEDESTRIAN BEHAVIOR

Pedestrian Compliance

Details of the study methods and instructions are provided in Volume 2, Appendix A, together with specific results. Pedestrian volume counts are contained in Volume 2, Appendix B.

Peak times for pedestrian and vehicle volumes were chosen for observations and data collection. For the San Carlos sites, the schedule of conventions at the nearby center was also taken into account. The expectation was that conference participants would provide study subjects that would not be regular users.

Proportion Waiting for the WALK

This part of the pedestrian compliance study consisted of assessing the proportion of pedestrians that arrived during the FDW display and waited for the WALK signal. The intent was to get some indication as to whether the countdown signal would cause those pedestrians arriving during the FDW to enter the crosswalk during the same phase.

The results are presented in Table 1. The percentages are based on the total number of pedestrians that arrived at the crosswalk during the FDW display (those that entered plus those that waited for the next WALK interval). The percentages of pedestrians that arrived during the FDW interval and waited for the next WALK interval decreased significantly at three of the four intersections (statistically different at the five percent level of significance). This trend was more pronounced for the 21st/Santa Clara and Market/St. John intersections. The pedestrians at these intersections are more likely to be regular users and may have become familiar with the countdown signals. It should be noted that the number of pedestrians waiting on the FDW is relatively small compared to the total number entering.

Table 1. Pedestrian Compliance Summary -- Waiting To Cross

Location	Number of pedestrians arriving at crosswalk during the FDW display		% of pedestrians (arriving during FDW) that waited for WALK display		
	Before	After	Before	After	Difference
Market & San Carlos	296	279	14.9%	8.6%	-6.3%
Santa Clara & 21st	106	210	18.9%	2.9%	-16.0%
Convention Ctr & San Carlos	69	151	11.6%	11.9%	0.3%
Market & St. John	79	220	41.8%	9.1%	-32.7%

From the above discussion, it may be concluded that the countdown signal may be causing people to enter the intersection on the FDW (perhaps when the countdown still displays a high number that causes the pedestrians to believe that they can still safely cross the intersection).

Proportion Entering Crosswalk During the WALK, FDW & DW Displays

The total numbers of pedestrians entering selected crosswalks on the WALK, FDW and the DW displays, respectively, were recorded. The results are summarized in Table 2. The proportion of entries on FDW increased for all four intersections. On the DW interval, the proportion of entries decreased at three of the intersections. The fact that proportionally more pedestrians entered on the FDW could be construed to mean that the new signal causes them to enter the crosswalk during the FDW display. It should be noted though that the differences are relatively small and are not statistically different at the five percent level of significance.

Table 2. Pedestrian Compliance Summary – Entering Crosswalk

Location	Number of Pedestrians Observed		% of Pedestrians Entering on WALK			% of Pedestrians Entering on FDW			% of Pedestrians Entering on DW		
	Before	After	Before	After	Diff.	Before	After	Diff.	Before	After	Diff.
Market & San Carlos	2038	1695	78.7%	76.3%	-2.4%	12.4%	15.0%	2.7%	8.9%	8.6%	-0.3%
Santa Clara & 21st	482	1113	72.6%	73.4%	0.8%	17.8%	18.3%	0.5%	9.5%	8.3%	-1.3%
Conv Ctr & San Carlos	464	933	49.8%	49.9%	0.2%	13.1%	14.3%	1.1%	37.1%	35.8%	-1.3%
Market & St. John	406	1599	82.3%	79.4%	-2.9%	11.3%	12.5%	1.2%	6.4%	8.1%	1.7%

Proportion Exiting Crosswalk During the WALK, FDW & DW Displays

The numbers of pedestrians exiting the crosswalk on the WALK, FDW and DW were observed; Table 3 contains a summary of the results.

Table 3. Pedestrian Compliance Summary -- Exiting Crosswalk

Location	Number of Pedestrians Observed		% of Pedestrians Exiting on WALK			% of Pedestrians Exiting on FDW			% of Pedestrians Exiting on DW		
	Before	After	Before	After	Diff.	Before	After	Diff.	Before	After	Diff.
Market & San Carlos	1993	1673	0.7%	0.9%	0.2%	86.0%	87.9%	2.0%	13.4%	11.2%	-2.2%
Santa Clara & 21st	484	1101	33.9%	30.2%	-3.7%	48.3%	55.9%	7.6%	17.8%	13.9%	-3.9%
Conv Ctr & San Carlos	463	909	7.8%	5.1%	-2.7%	62.0%	69.1%	7.1%	30.2%	25.9%	-4.4%
Market & St. John	406	1586	28.1%	23.3%	-4.8%	59.6%	67.5%	7.9%	12.3%	9.3%	-3.0%

The proportion of pedestrians exiting during the FDW indication increased at all of the sites, while the proportions exiting on the DW decreased. All increases were statistically different at the five percent level of significance. This may be an indication that pedestrians are changing their walking behavior and that they use the countdown as an indication of the need to increase their walking speed. From this viewpoint, the signal may be viewed as beneficial.

Unusual Behavior

The numbers of pedestrians running, stopping/hesitating or turning-around were recorded as well as the number of pedestrians involved in a conflict with a vehicle. A conflict was defined as any action by a vehicle that caused a change in the behavior of a pedestrian. The results are summarized in Tables 4 and 5.

The differences between the before and after results are relatively small and do not show a pattern. Moreover, since judgment was involved and different observers participated, the results may also be inconsistent.

Table 4. Pedestrian Compliance Summary -- Pedestrian Action

Location	Number of Pedestrians Observed		% of Pedestrians that Ran while Crossing			% of Pedestrians that Stopped/ Hesitated			% of Pedestrians that Turned Around/ Returned to Curb		
	Before	After	Before	After	Diff.	Before	After	Diff.	Before	After	Diff.
Market & San Carlos	2038	1695	3.6%	2.8%	-0.9%	1.1%	2.8%	1.6%	0.1%	0.1%	0.0%
Santa Clara & 21st	482	1113	2.3%	3.3%	1.0%	0.6%	0.8%	0.2%	0.4%	0.0%	-0.4%
Conv Ctr & San Carlos	464	933	5.4%	2.7%	-2.7%	5.2%	6.5%	1.4%	0.6%	0.1%	-0.5%
Market & St. John	406	1599	4.9%	2.7%	-2.2%	1.5%	0.6%	-0.9%	0.2%	0.1%	-0.1%

Table 5. Pedestrian Compliance Summary -- Conflicts

Location	Number of Pedestrians Observed		% of Pedestrians Delayed due to a Vehicle Conflict			% of Pedestrians Hurried due to a Vehicle Conflict		
	Before	After	Before	After	Difference	Before	After	Difference
Market & San Carlos	2038	1695	1.6%	2.4%	0.7%	1.1%	0.5%	-0.5%
Santa Clara & 21st	482	1113	0.6%	0.7%	0.1%	0.2%	0.6%	0.4%
Conv Ctr & San Carlos	464	933	5.0%	0.2%	-4.7%	0.0%	0.0%	0.0%
Market & St. John	406	1599	2.0%	0.4%	-1.6%	1.2%	0.3%	-1.0%

Pedestrian Walking Speeds

The details of the study procedure and results are presented in Volume 2, Appendix C.

Field studies were carried out to assess actual pedestrian crossing times at several intersections. Data were gathered at signalized intersections before the devices were installed and then again at the same intersections after countdown signals were placed. Pedestrians entering a crosswalk were observed, and their curb-to-curb time was recorded.

The data gathered in this portion of the study were collected to determine if, and to what extent, the presence of the countdown signal impacts pedestrian crossing speeds. The results are summarized in Table 6. Figures 7 and 8 illustrate the pedestrian movement codes referred to in Table 6.

Table 6. Walking Speeds Summary (Selected Intersections)

Location	Pedestrian Movement (see figures 7 and 8)	Before				After				Difference in Average Speed, ft/s
		No. of Samples	Distance, ft	Average Speed, ft/s	Standard Deviation	No. of Samples	Distance, ft	Average Speed, ft/s	Standard Deviation	
Market & St. John	A, B	9	98	6.7	1.07	3	98	6.9	0.58	0.1
	C, D	4	93	5.8	0.52	8	93	5.7	1.02	-0.1
	E, F	24	88	5.7	1.43	71	88	5.8	1.15	0.1
	G, H	15	84	5.8	1.62	0	84	n/a	n/a	n/a
	Summary	52	n/a	5.9	1.41	82	n/a	5.8	1.14	-0.1
Santa Clara & 21st	A, B	86	38	4.3	0.70	52	38	4.9	1.06	0.6
	C, D	13	45	4.2	0.96	17	45	3.6	0.73	-0.6
	G, H	17	38	3.8	0.88	20	38	3.8	0.52	0.0
	G, H	63	45	3.7	0.98	64	45	4.1	1.44	0.4
	Summary	179	n/a	4.0	0.88	153	n/a	4.3	1.24	0.2
Conv Ctr & San Carlos	C	86	100	4.6	0.82	61	100	4.4	1.34	-0.2
	C1	42	25	3.5	0.62	19	25	3.2	0.90	-0.4
	C2	53	33	4.7	1.23	7	33	4.2	1.00	-0.5
	D	5	100	6.6	1.78	9	100	4.4	1.00	-2.2
	D1	3	33	3.9	0.87	1	33	3.0	n/a	-0.9
	D2	6	25	3.4	0.76	7	25	3.2	1.28	-0.2
	Summary	195	n/a	4.4	1.11	104	n/a	4.1	1.29	-0.3

Figure 7. Movement Codes (Standard Intersections)

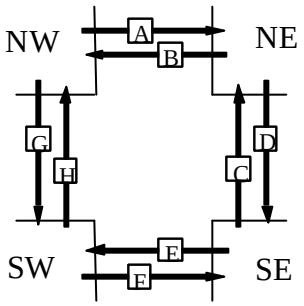
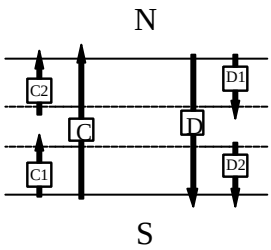


Figure 8. Movement Codes (Convention Center & San Carlos)



Data from this portion of the study indicate that pedestrians' crossing speeds are negligibly affected by the presence of the countdown signal. It is notable that the differences in walking speeds are much greater when the walking speeds for the different sites are compared. This reinforces the conclusion that the countdown does not significantly affect walking speeds.

Pedestrian Surveys

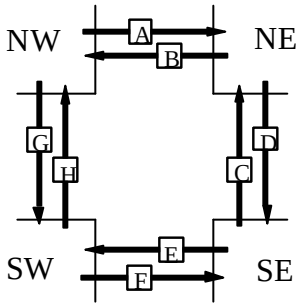
Four short surveys were designed to gather data on pedestrians' interpretations of various intersection features. Pedestrians were selected at random from those who were approaching the curb to cross at an intersection. The specific instructions, survey forms, and details of the results are presented in Volume 2, Appendix D.

Survey 1: Perception of Crossing Time / Frequency of Crosswalk Use

The purpose of this survey was to determine whether pedestrians could accurately estimate the time necessary to traverse an intersection. This survey was conducted at two separate intersections where no countdown signal was present. The reason for using intersections without countdown signals for data collection was to eliminate bias from people knowing the design clearance time, which they would have been able to see at intersections with a countdown device. Data were collected at Market & Santa Clara Streets, and also at the intersection of Almaden Avenue & San Carlos Street. The observations were made when large numbers of pedestrians were expected such as during convention center events.

Pedestrians were asked how many seconds they thought it would take to cross these intersections and also how often they used the intersection (daily, weekly, monthly, or just that day).
A summary of the results is shown in Tables 7 and 8. The adjusted standard deviation was measured, where applicable, by discarding the outliners, which were two or more times larger than the next highest response.

Figure 7. Movement Codes (Standard Intersections)



The perceived average crossing times for the crosswalks range from about three to ten seconds below the design clearance time. Additionally, the intersection width for movements B and F (see Figure 7) are similar, as are widths for movements D and H; however, average perceived times for B and F turned out to be dissimilar, as did average times for D and H. The results indicate

that pedestrians do not have a good sense of the time necessary to traverse an intersection. Also, a wide range of responses was received, but the standard deviation is reasonably small. The latter result probably stems from the fact that 64 percent of the pedestrians are daily users.

Table 7. Pedestrian Perception Of Crossing Time

Location	Pedestrian Movement (see fig. 7)	Pedestrian Clearance Time (seconds)	Number of Responses	Average	Standard Deviation	Adjusted Average	Adjusted Standard Deviation	Adjusted Range (seconds)
Market & Santa Clara	B	18	12	18.67	14.83	13.67	7.51	5~30
	D	19	21	20.48	27.53	9.05	4.57	5~20
	F	18	8	11.88	7.88	11.88	7.88	5~30
	H	19	11	15.45	7.15	15.45	7.15	5~30
Almaden & San Carlos	C	28	14	13.36	5.75	13.36	5.75	5~25
	E	33	6	20.33	8.36	20.33	8.36	9~35

Table 8. Frequency Of Crosswalk Use Corresponding To Perception Of Crossing Time

Location	Movement (see fig. 7)	Frequency of Crosswalk Use				
		No. of Responses	Daily	Weekly	Monthly	Just Today
Market & Santa Clara	B	12	8	1	1	2
	D	21	19	2	0	0
	F	8	8	0	0	0
	H	11	11	0	0	0
	Summary	52 (100%)	46 (88%)	3 (6%)	1 (2%)	2 (4%)
Almaden & San Carlos	C	14	0	2	3	9
	E	6	0	0	1	5
	Summary	20 (100%)	0 (0%)	2 (10%)	4 (20%)	14 (70%)
Overall Summary	**All**	**72 (100%)**	**46 (64%)**	**5 (7%)**	**5 (7%)**	**16 (22%)**

Overall, it may be concluded that pedestrians do not have a reasonably good sense of clearance time, and they may be unable to distinguish clearly between the time required for wider streets and that required for narrower streets.

Survey 2: Understanding of Flashing Hand Display (Without Countdown)

The purpose of this survey was to determine whether pedestrians understand the message

provided by traditional FDW displays without countdown devices. This survey was conducted at Market & Santa Clara Streets where no countdown signals were present.
Pedestrians were shown a figure of the upraised hand symbol and asked whether or not they believe it is permitted to enter the crosswalk when the symbol is flashing.

A summary of the results is shown in Table 9. Data collected at these intersections indicate that a large majority of pedestrians properly interpret the FDW display (without countdown), i.e., that it is not permitted to enter the intersection on the FDW.

Table 9. Pedestrian Understanding Of Flashing Hand Display (Without Countdown)

Location	Pedestrian Responses		Response Percentages	
	Permitted to Cross	Not Permitted to Cross	Permitted to Cross	Not Permitted to Cross
Market & Santa Clara	13	39	**24%**	**76%**

Survey 3: Understanding of Flashing Hand Display (With Countdown)

The purpose of this survey was to determine whether pedestrians understand the message provided by pedestrian signal displays with countdown devices. This survey, which was conducted at an intersection where a pedestrian countdown signal was present, differs from Survey 2 only in that the question references a signal with a countdown device, rather than without. Data were collected at the intersection of Market & St. John Streets.

Pedestrians were shown a figure of the upraised hand symbol with adjacent countdown display and asked whether or not they believed it is permitted to enter the crosswalk when the symbol is flashing. The results of the survey are summarized in Table 10.

Table 10. Pedestrian Understanding Of Flashing Hand Display (With Countdown)

Location	Pedestrian Responses		Response Percentages	
	Permitted to Cross	Not Permitted to Cross	Permitted to Cross	Not Permitted to Cross
Market & St. John	23	33	**41%**	**59%**

Data collected at this intersection indicate that pedestrians properly interpret the FDW display about 59 percent of the time. It is of interest that, in Survey 2, which was conducted at an intersection with traditional flashing-hand displays, pedestrians properly interpreted the signal 76 percent of the time. These results indicate that the misunderstanding of the conventional FDW display increases with the presence of the countdown display.

Survey 4: Meaning of the Countdown

The objective of this survey was to understand pedestrian perception of the meaning of a countdown display, in the context of whether it signifies that they can enter on the FDW.

The surveyor gestured toward a countdown signal, in the process of counting down, then asked pedestrians about the meaning of the countdown display. They were asked whether they could begin crossing the intersection if they could finish before the timer counted down to zero or if they should instead wait for the next WALK signal. They were also asked the frequency with which they use that particular crosswalk. The results of the survey are summarized in Table 11.

Table 11. Pedestrian Understanding Of Meaning Of The Countdown

Location	Pedestrian Responses		Frequency of Crosswalk Use			
	Walk if Finish Before Zero	Wait for Next WALK Signal	Daily	Weekly	Monthly	Just Today
Market & St. John	24	3	18	3	3	3
Conv Ctr & San Carlos	21	8	9	17	1	2
Total	**45 (80%)**	**11 (20%)**	**27 (48%)**	**20 (36%)**	**4 (7%)**	**5 (9%)**

Data collected at this intersection indicate that most pedestrians improperly interpret the countdown display. Eighty percent of the respondents said that they could begin the crossing if they thought they could finish before it counted down to zero. This would indicate that the intended meaning of this type of signal is widely misunderstood and that the signal may cause pedestrians to enter the intersection during the FDW.

MOTORIST BEHAVIOR

The numbers of motorists entering the intersection on yellow or red were monitored to determine whether the presence of the new signal increased the proportion of motorists entering on yellow or red. Both the associated direction (in the same direction as the FDW and or countdown display) and the opposing direction (crossing the associated direction) were observed. However, observation of the opposing direction was abandoned soon after the study commenced, because the number of violations was insignificant. Volume 2, Appendix E contains the details of the study procedures and results. Vehicle volume counts were conducted at the same time. The counts are presented in Volume 2, Appendix B.

The results for entries on the yellow are shown in Table 12, for red in Table 13, and for yellow and red combined in Table 14. In all three tables it can be seen that the proportion of violations decreased after the countdown signals were installed. Since the differences are small and there would not appear to be a logical explanation for the decrease, it may be concluded that there was no discernable negative effect from the installation of the signal.

Table 12. Motorist Behavior -- Entering Intersection During Yellow

Location	Total Number of Vehicles Entering Intersection (during period observed)		% of Vehicles Entering Intersection During Yellow Indication		
	Before	After	Before	After	Difference
Market & San Carlos	7339	22162	2.2%	0.7%	-1.5%
Santa Clara & 21st	5269	13246	0.9%	1.9%	1.0%
Market & St. John	3243	14741	1.1%	0.6%	-0.5%

Table 13. Motorist Behavior -- Entering Intersection During Red

Location	Total Number of Vehicles Entering Intersection (during period observed)		% of Vehicles Entering Intersection During Red Indication (excluding permitted right-turns on Red)		
	Before	After	Before	After	Difference
Market & San Carlos	7339	22162	0.3%	0.2%	-0.1%
Santa Clara & 21st	5269	13246	0.6%	0.5%	-0.1%
Market & St. John	3243	14741	0.2%	0.1%	-0.1%

Table 14. Motorist Behavior -- Entering Intersection During Yellow Or Red

Location	Total Number of Vehicles Entering Intersection (during period observed)		% of Vehicles Entering Intersection During Yellow or Red (excluding permitted right-turns on Red)		
	Before	After	Before	After	Difference
Market & San Carlos	7339	22162	2.5%	0.9%	-1.6%
Santa Clara & 21st	5269	13246	1.5%	2.4%	0.9%
Market & St. John	3243	14741	1.4%	0.7%	-0.6%

TRAFFIC CONFLICT AND CRASH ANALYSIS

Crash Analysis

An analysis of crashes involving pedestrians and bicyclists was carried out at the intersections where the countdown signal was installed, for a period of three years before the installation and for periods varying from four to seven months after the installation. The primary purpose was to determine whether the countdown signal resulted in any difference in the crash occurrences at the intersections.

The crash reports were reviewed to determine whether a misinterpretation of the FDW display played a role in crash patterns. A total of 24 crash reports were reviewed for the before period. No reported crashes occurred during the after installation period. No evidence was found that misinterpretation of the FDW played a role in any of the crashes.

Traffic Conflicts

Pedestrian-vehicle conflicts were recorded to gain some additional perspective on the safety performance of the intersections during both the before and after installation situations. For the purpose of this portion of the study, a conflict was defined as an event when either a pedestrian or a vehicle was delayed as a result of an unlawful action by a pedestrian or a vehicle. Conflicts were recorded during the before and after periods for selected crosswalks and intersections. Volume 2, Appendix F contains the details of the study procedures and results.

The results are summarized in Tables 15 through 18. Relatively few conflicts were observed and it can be concluded that the differences between the before and after installation conflict rates are relatively small. However, there are a few movements (see Tables 15 and 16) where the differences are more pronounced and indicate that the countdown signal may have a beneficial effect, i.e. the conflict rate is reduced in the after installation period. It should be noted, however

that the collection of these data requires judgment on the collector's part. Since several people collected data, there may be some bias in the results.

Table 15. Traffic Conflicts Summary – Vehicles Approaching From The West

Location	Right Turn			Left Turn			Straight Near			Straight Far		
	Before	After	Diff.	Before	After	Diff.	Before	After	Diff.	Before	After	Diff.
Number of Conflicts												
Market & San Carlos	48	19		2	n/a		1	4		0	1	
Santa Clara & 21st	1	0		0	0		3	1		0	0	
Conv Ctr & San Carlos	n/a	n/a		n/a	n/a		5	6		n/a	n/a	
Market & St. John	7	9		2	5		0	0		0	0	
Number of Conflicts per Hour												
Market & San Carlos	6.0	1.9	-4.1	0.3	n/a	n/a	0.1	0.4	0.3	0.0	0.1	0.1
Santa Clara & 21st	0.3	0.0	-0.3	0.0	0.0	0.0	0.8	0.2	-0.6	0.0	0.0	0.0
Conv Ctr & San Carlos	0.0	0.0	0.0	0.0	0.0	0.0	2.0	1.5	-0.5	0.0	0.0	0.0
Market & St. John	4.7	1.1	-3.5	1.3	0.6	-0.7	0.0	0.0	0.0	0.0	0.0	0.0

Table 16. Traffic Conflicts Summary – Vehicles Approaching From The East

Location	Right Turn			Left Turn			Straight Near			Straight Far		
	Before	After	Diff.	Before	After	Diff.	Before	After	Diff.	Before	After	Diff.
Number of Conflicts												
Market & San Carlos	4	n/a		0	n/a		0	n/a		0	n/a	
Santa Clara & 21st	2	1		1	0		0	1		0	2	
Conv Ctr & San Carlos	n/a	n/a		n/a	n/a		9	0		n/a	n/a	
Market & St. John	0	3		17	28		1	0		0	1	
Number of Conflicts per Hour												
Market & San Carlos	0.7	n/a	n/a	0.0	n/a	n/a	0.0	n/a	n/a	0.0	n/a	n/a
Santa Clara & 21st	0.5	0.2	-0.3	0.3	0.0	-0.3	0.0	0.2	0.2	0.0	0.3	0.3
Conv Ctr & San Carlos	n/a	n/a	n/a	n/a	n/a	n/a	3.6	0.0	-3.6	n/a	n/a	n/a
Market & St. John	0.0	0.4	0.4	11.3	3.5	-7.8	0.7	0.0	-0.7	0.0	0.1	0.1

Table 17. Traffic Conflicts Summary – Vehicles Approaching From The North

Location	Right Turn			Left Turn			Straight Near			Straight Far		
	Before	After	Diff.	Before	After	Diff.	Before	After	Diff.	Before	After	Diff.
Number of Conflicts												
Market & San Carlos	12	19		3	1		1	18		1	2	
Santa Clara & 21st	0	2		3	7		1	2		1	0	
Conv Ctr & San Carlos	n/a	n/a		n/a	n/a		n/a	n/a		n/a	n/a	
Market & St. John	0	0		2	3		0	1		0	5	
Number of Conflicts per Hour												
Market & San Carlos	1.5	1.9	0.4	0.4	0.1	-0.3	0.1	1.8	1.7	0.1	0.2	0.1
Santa Clara & 21st	0.0	0.3	0.3	0.8	1.2	0.4	0.3	0.3	0.1	0.3	0.0	-0.3
Conv Ctr & San Carlos	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Market & St. John	0.0	0.0	0.0	1.3	0.4	-1.0	0.0	0.1	0.1	0.0	0.6	0.6

Table 18. Traffic Conflicts Summary – Vehicles Approaching From The South

Location	Right Turn			Left Turn			Straight Near			Straight Far		
	Before	After	Diff.	Before	After	Diff.	Before	After	Diff.	Before	After	Diff.
Number of Conflicts												
Market & San Carlos	5	n/a		6	5		4	n/a		1	n/a	
Santa Clara & 21st	2	2		4	3		3	0		0	0	
Conv Ctr & San Carlos	n/a	n/a		n/a	n/a		n/a	n/a		n/a	n/a	
Market & St. John	1	2		0	1		0	5		0	1	
Number of Conflicts per Hour												
Market & San Carlos	0.8	n/a	n/a	0.8	0.5	-0.3	0.7	n/a	n/a	0.2	n/a	n/a
Santa Clara & 21st	0.5	0.3	-0.2	1.0	0.5	-0.5	0.8	0.0	-0.8	0.0	0.0	0.0
Conv Ctr & San Carlos	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Market & St. John	0.7	0.3	-0.4	0.0	0.1	0.1	0.0	0.6	0.6	0.0	0.1	0.1

PRACTICE FOR PEDESTRIAN SIGNAL TIMING IN CALIFORNIA

Practices for calculating the pedestrian clearance interval, and timing the FDW interval, vary among California jurisdictions. The distance pedestrians travel to cross a street (in feet), divided by four (feet per second), is a generally accepted method of calculating the pedestrian clearance interval. But there is some flexibility in determining the distance across a street, as well as including vehicle yellow time in the pedestrian clearance interval when timing the FDW interval.

Inquiries to several California municipalities illustrate the variations in these practices. Both the City of San Jose and the City of Stockton do not include vehicle yellow time in the pedestrian clearance interval and generally measure the crosswalk from curb to curb when calculating the time of the FDW interval. The City of Berkeley does not include yellow time in the pedestrian clearance interval and generally measures the crosswalk from curb to the middle of the farthest traveled lane. The City of Fountain Valley includes yellow time in the pedestrian clearance interval and generally measures the crosswalk from curb to curb. The City of Oakland includes yellow time in the pedestrian clearance interval and generally measures the crosswalk from curb to curb, subtracting the parking lane width (at far end) and half of the farthest traveled lane. The City of Walnut Creek generally includes yellow time in the pedestrian clearance interval (except at certain intersections such as school and hospital crossings), and crosswalks are measured from curb to the middle of the farthest traveled lane.

These various practices affect the initial time displayed by the countdown signals. For example, a countdown signal accompanying the FDW interval for a crosswalk measuring 80 feet from curb to curb, 68 feet from curb to middle of farthest lane, with a 4 second vehicle yellow time, would begin counting down at 20 (in San Jose and Stockton), at 17 (in Berkeley), at 16 (in Fountain Valley), and at 13 (in Walnut Creek and Oakland). In all of these cases, current pedestrian signal timing guidelines are complied with, although the amount of time pedestrians have to cross once the FDW is displayed would be different depending upon the jurisdiction. However, it should be noted that if the pedestrian were to see 13 seconds on the countdown device in Walnut Creek and San Jose respectively, the remaining time to cross would be the same, notwithstanding the fact that the start time in San Jose would be 20 seconds.

SUMMARY OF MAJOR FINDINGS

The following are major findings identified in the study:

Pedestrian Behavior

- The percentage of pedestrians that arrived during the FDW interval and waited for the walk signal decreased significantly after the countdown signal was introduced. This trend was more pronounced at intersections where there were likely to be more regular users adjusting to the new signals. The countdown signal may be causing people to enter the intersection on the FDW, particularly when the countdown still displays a high number, by making pedestrians feel that they can still safely cross the intersection.
- The proportion of entries on FDW increased for all intersections, but the differences were relatively small. The proportion of pedestrians exiting during the FDW indication increased at all of the sites, while the proportions exiting on the DW decreased. This may be an indication that pedestrians used the information conveyed by the timer to adjust their walking speeds in order to clear the intersection before the DW phase.
- There was little difference in the before-and-after proportions of unusual activity, i.e. of pedestrians running, stopping/hesitating turning-around and pedestrians involved in a conflict with a vehicle. A conflict was defined as any action by a vehicle that caused a change in the behavior of a pedestrian.
- Pedestrians' crossing speeds were negligibly affected by the presence of the countdown signal. The change in average walking speeds from before to the after installation, at individual intersections, is small compared to the variation of walking speeds among different intersections. This leads to the conclusion that other factors have a far greater effect on walking speeds than the countdown signal. Those factors can vary and were not recorded in this report.
- Pedestrians do not have a reasonably good sense of clearance time, and they may be unable to distinguish clearly between the time required for wider streets and that required for narrower streets.

- At locations without a countdown signal, when pedestrians were asked whether it was permitted to enter a crosswalk on the FDW, 76 percent correctly responded "no". When the same question was asked at location with a countdown device, 59 percent correctly responded "no". This disparity in understanding of the signals indicates that the countdown device may result in pedestrians believing that they may enter the intersection during the FDW. When the question was posed in a different way, i.e. whether one was allowed to enter the crosswalk on FDW if the crossing could be completed before the countdown went to zero, 80 percent incorrectly responded "yes". This also indicates that more pedestrians believe it is permitted to enter the crosswalk during the FDW display with a countdown signal.

Motorist Behavior

Observation of motorist signal violations (entering in yellow or red) showed no discernable negative effect from the installation of the signal.

Safety Performance

An analysis of crash reports for a period of approximately three years before the installation of the signal and approximately four to seven months after, showed no evidence that misinterpretation of the FDW or the countdown device played a role in any of the crashes.

The pedestrian-vehicle conflict study, wherein a conflict was defined as an event when either a pedestrian or a vehicle was delayed as a result of an unlawful action by a pedestrian or a vehicle, showed that the differences between the before and after conflict rates (conflicts per hour) are relatively small. There are a few movements where the differences were more pronounced and indicate that the countdown signal may have a beneficial effect, i.e. the conflict rate is reduced in the after period. It should be noted, however that the collection of these data requires judgment on the collector's part. Since several people collected data, there may be some bias in the results.

DISCUSSION OF MAJOR FINDINGS

The studies of pedestrian behavior indicated that the presence of a countdown signal caused more pedestrians to enter the crosswalk on the FDW indication, which may be viewed as negative since it results in an unlawful action. It can also cause some pedestrians to step into the crosswalk and not be able to clear the intersection before being confronted with a conflicting green indication for vehicles. However, there was also an indication that a larger proportion of pedestrians are now completing their crossing on the FDW. This result may be construed as positive, since it would seem that more pedestrians get out of the crosswalk before the DW and are using the additional information provided by the countdown signal to complete their crossings in the time provided. It should be noted, that completing a crossing before the DW reduces the chances for pedestrians to be confronted with conflicting vehicle movements. This reduction appears to be greater than the increased proportion of pedestrians entering the crosswalk during the FDW.

The pedestrian survey results showed that the pedestrians interpreted the meaning of the FDW indication, when used in conjunction with the countdown signal, differently than they interpreted the FDW indication with no accompanying countdown device. Pedestrians appear to believe that it is permitted to cross if they can complete the crossing before the countdown reaches zero. This may be an indication that pedestrians believe the countdown signal provides more information from which to make a decision, thus shifting the importance from the FDW display to the countdown signal.

These conclusions are generally borne out by the results obtained in other studies.

RECOMMENDATIONS

It should be kept in mind that the real benefits of a countdown signal would consist of a reduction in pedestrian-related crashes connected to the new signal. Determining the extent of such benefits would probably be difficult in the short term, since pedestrian-related crashes are relatively rare occurrences and establishing a reliable database would require an extensive effort over several years. It is therefore unlikely that substantially better data will become available soon for decision-making regarding the implementation of the countdown signal. Consequently, the results of current studies will therefore have to suffice. Since there are apparently both advantages and disadvantages to the implementation of the countdown signal in its current form, an appropriate strategy may be to implement the signal but to address the associated problems directly.

Potential solutions could include educating the public on the meaning of the countdown display and modification of the countdown signal to display the initial walk interval (counting down) in green, followed by the pedestrian clearance interval (counting down) in red, without the conventional pedestrian symbols.

REFERENCES

1. Huang, H., Zegeer, C. *An Evaluation of Pedestrian Countdown Signals.* A Report Prepared by The University of North Carolina at Chapel Hill Highway Safety Research Center for the Federal Highway Administration. February 1999.

2. *California Vehicle Code.* California Department of Motor Vehicles. http://www.dmv.ca.gov/pubs/vctop/d11/vc21456.htm

3. *Canadian Research on Pedestrian Safety.* U.S. Department of Transportation. Pub. No. FHWA-RD-99-090. McLean, VA. December 1999.

4. *San Francisco Pedestrian Countdown Signals: Preliminary Evaluation Summary.* A Report Prepared by DKS Associates for the San Francisco Department of Parking and Traffic. September 13, 2001.

5. Bower, Nancy. "What Works in Big Cities?" Online posting. Center for Transportation Policy, NYU. http:///www.bikefed.org/abstracts/ab_46.html

6. Leonard, J., Juckes, M., Clement, B. *Safety & Behavior: Behavioral Evaluation of Pedestrians and Motorists Towards Pedestrian Countdown Signals.* A Report Prepared by Dessau-Soprin Inc. for the City of Monterey, California. March 1999.

7. *Countdown Pedestrian Indication Market Research.* A Report Prepared by Cook Research & Consulting, Inc. for the City of Minneapolis, Minnesota. June 1999.

8. *Transportation Research and Development Project Page*. Quebec Ministere des Transports. http://www.mta.gouv.qc.ca/projet/tab/I040_1_en.htm